INSIGHT

Trial Exam Paper

2011

BIOLOGY

Written examination 2

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*	*Suggested times (minutes)*
A	25	25	25	30
B	8	8	50	60
			Total 75	90

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.

Materials provided

- The question and answer book of 33 pages.
- An answer sheet for multiple-choice questions.

Instructions

- Write your **name** in the box provided and on the answer sheet for multiple-choice questions.
- You must answer the questions in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions in the front cover of the question and answer book.

Students are NOT permitted to bring mobile phones or any other electronic devices into the examination.

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SECTION A – MULTIPLE-CHOICE QUESTIONS

Question 1

In bilbies (*Macrotis lagotis*), males and females show a different number of diploid chromosomes. The male has a diploid number of 19, whereas the female has a diploid number of 18. The number of autosomes present in a single normal oocyte is

A. 18

B. 19

C. 8

D. 9

Question 2

In a human with a normal karyotype, variation can arise from

A. replication of chromosomes during early prophase.

B. exchange of genetic information during crossing over.

C. non-disjunction of chromosomes during anaphase.

D. undergoing mitotic division.

Question 3

On a chromosome, the position occupied by a gene is its _____. Variants of genes, known as _____ can be found at these positions.

A. allele, homologues

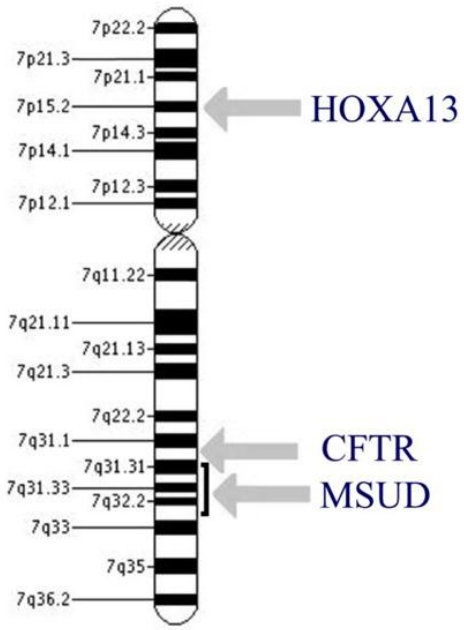
B. locus, homologues

C. allele, loci

D. locus, alleles

The following information relates to Questions 4 and 5.

The diagram shows a map of a particular human chromosome showing the cystic fibrosis transmembrane conductance regulator (CFTR) gene. The CFTR gene codes for the production of the CFTR protein, which functions as an ion channel within the cell membrane. The CFTR protein occurs in tissue that produces mucus, sweat, saliva, tears, and digestive enzymes. Two other genes are also shown.



Question 4

According to the system of identification used in chromosome mapping, the CFTR gene is

A. found on chromosome number 7.

B. located on the short arm of the chromosome.

C. approximately 31 base pairs in length.

D. positioned in the second region of the long arm of the chromosome.

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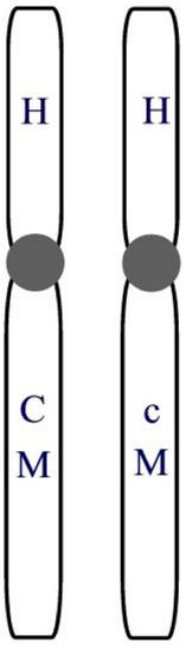
Question 5

A pair of homologous chromosomes involved in normal meiosis in the testes carries the alleles for the HOXA13 (H), CFTR (C) and MSUD (M) genes.



Chromosomes found in the sperm produced would be

A.

B.

C.

D.

The following information relates to Questions 6 and 7.

A hairless hamster is bred with a normal haired hamster. Twelve pups are born in the litter, seven of the pups are hairless and five pups are normal haired. When a pair of the hairless hamsters are interbred, the litter produced also has twelve pups, four of which are normal haired and eight of which are hairless.

Question 6

The results of the first cross between the hamsters indicate a cross between

A. heterozygote x heterozygote.

B. homozygote x homozygote

C. heterozygote x homozygote.

D. hemizygote x homozygote.

Question 7

The results of the cross between the two hairless hamsters suggests that the

A. heterozygous genotype may be lethal.

B. homozygous recessive genotype may be lethal.

C. hairless hamsters have hemizygous genotypes.

D. hairless hamsters have homozygous genotypes.

Question 8

The phase of meiosis most directly related to Mendel's law of independent assortment is

A. prophase I.

B. metaphase I.

C. anaphase II.

D. telophase II.

Question 9

A plasmid has two genes for antibiotic resistance, one for tetracycline and one for ampicillin. It is treated with a restriction enzyme that makes a cut in the middle of the ampicillin gene. DNA fragments containing a human globin gene were cut with the same enzyme. The plasmids and fragments are mixed, treated with ligase and used to transform bacterial cells. Clones that have taken up the recombinant DNA are those that

A. can grow on plates with tetracycline but not ampicillin.

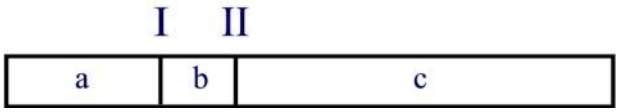
B. can grow on plates with both antibiotics.

C. can grow on plates with ampicillin but not tetracycline.

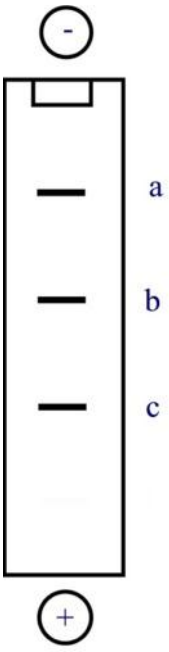
D. cannot grow with any antibiotics.

Question 10

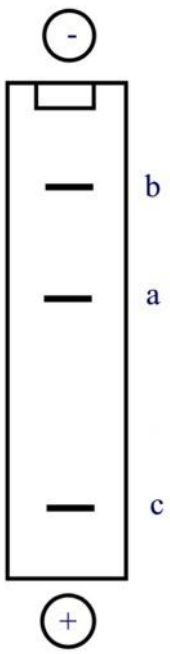
A segment of DNA has been cut with a restriction enzyme to produce the fragments *a*, *b* and *c*. Which of the following electrophoresis gels represents the separation and identity of these fragments?



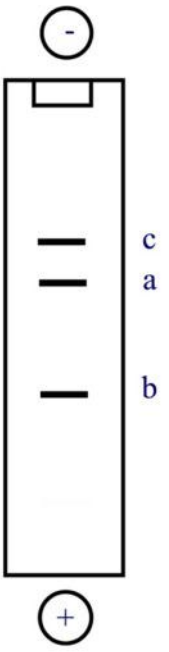
A.



B.



C.



D.

Question 11

Four students were asked to contribute information about chromosomes and plasmids to a class revision guide at the end of the semester. Which information should be **excluded** from the revision guide?

	plasmid	**prokaryote chromosome**	**eukaryote chromosome**
A.	circular	circular	linear
B.	no histones present	no histones present	histones present
C.	single stranded	single stranded	double stranded
D.	replicated independently of binary fission	replicated through binary fission	replicated during mitosis or meiosis

Question 12

DNA helicase is an enzyme that

A. untwists the double strands of DNA at the replication forks making them available as templates.

B. enables the copying of DNA from an existing template.

C. breaks, swivels and rejoins DNA strands to relieve strain in the double helix ahead of the replication fork during replication.

D. makes a primer by joining RNA nucleotides whilst using the parental DNA strand as a template.

Question 13

In DNA, a short tandem repeat (STR) occurs when a pattern of two or more nucleotides is repeated and the sequence of repeats occurs directly adjacently. DNA from STRs is unique to individuals which means it can be used to match DNA from a crime scene to a single person. It would not be possible to use this method of DNA profiling if the suspect

A. was a dizygotic twin.

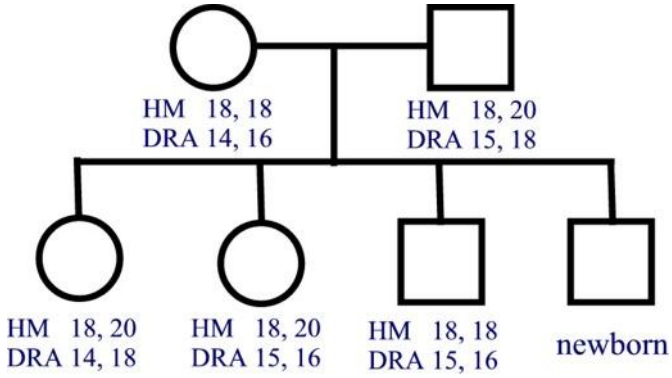
B. was a monozygotic twin.

C. had no living relatives**.**

D. had only left saliva samples at the scene of the crime.

The following information relates to Questions 14 and 15.

In a hospital, the identification wrist bands in a maternity ward were faulty and fell off several newborn infants. The hospital staff rebanded the babies. However, in order to confirm that the identities of the babies were not mixed up, DNA analysis of two minisatellite loci (locus HM and locus DRA) was carried out for each of the families involved. The results for one family are shown in the pedigree below. Assume that no mutation involving these two loci has occurred in the family.



Question 14

The result which confirms that the newborn belongs to the family above is

A. HM 20, 20, DRA 14, 18.

B. HM 18, 20; DRA 15, 18.

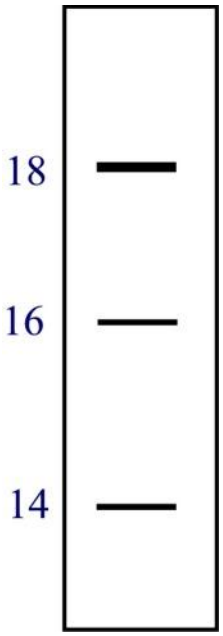
C. HM 18, 20; DRA 14, 16.

D. HM 18, 20; DRA 16, 18.

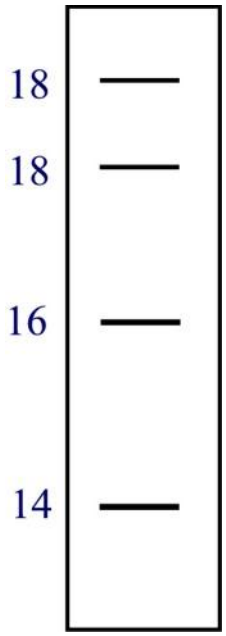
Question 15

Which diagram shows the simplified DNA fingerprint of the mother?

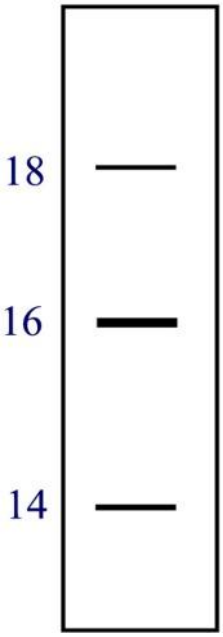
A.



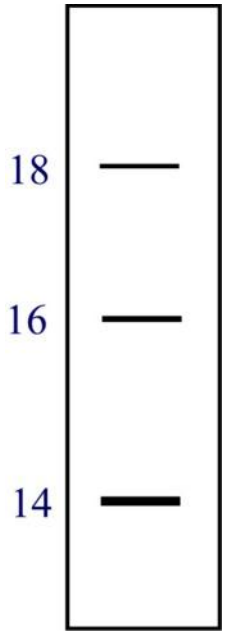
B



C.



D.



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Question 16

On the Hawaiian Archipelago there are 28 morphologically diverse species of a group of sunflowers called silverswords. These species are an example of

A. the founder effect.

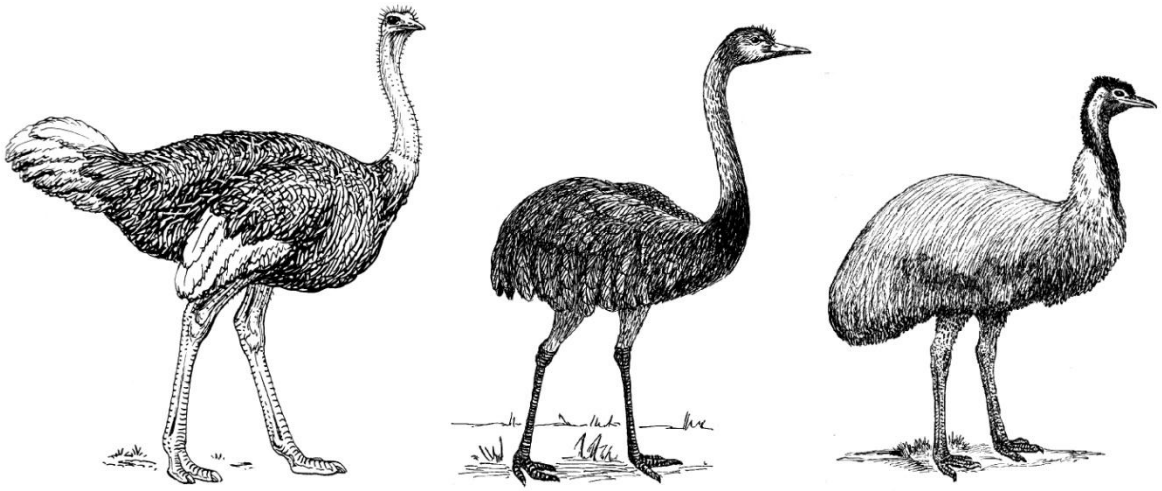
B. convergent evolution.

C. divergent evolution.

D. the bottleneck effect.

Question 17

Three ratites, the ostrich, rhea and emu are ecologically similar extant species of bird.



In determining the phylogeny of these three birds, the best data could be obtained from

A. a quantitative analysis of morphological similarities and differences.

B. the fossil record.

C. a comparison of embryological development.

D. a comparison of DNA sequences.

Question 18

The budgerigar *Melopsittacus undulatus* and the chimpanzee *Pan paniscus* are vertebrates and both have four appendages. This is an example of

A. a shared ancestral character.

B. a shared derived character.

C. analogy rather than homology.

D. a character useful for distinguishing birds from mammals.

Question 19

In human populations no two individuals are identical, with the exception of identical twins. The principle cause of genetic variation amongst humans is due to

A. genetic drift due to the small size of the population.

B. new mutations that arise in the preceding generation.

C. the reshuffling of alleles in sexual reproduction.

D. geographic variation within the population.

Question 20

The time course of speciation has been described as punctuated or gradual. According to the punctuated equilibrium model

A. evolutionary change occurs almost unnoticeably and slowly over a long period of time.

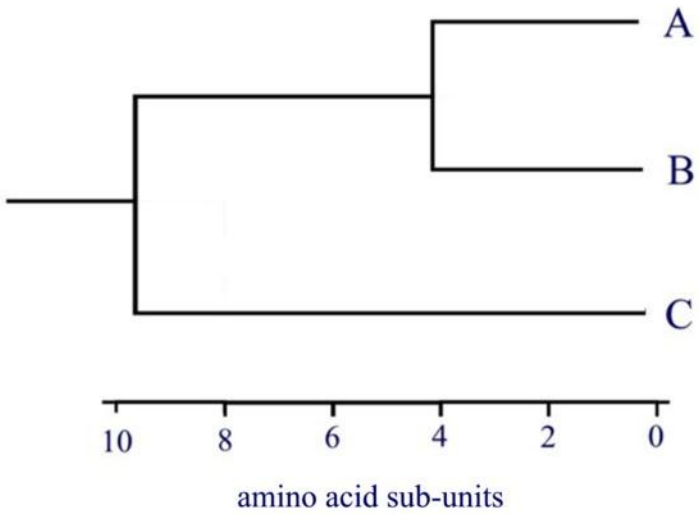
B. evolutionary change occurs rapidly over short periods of time, interspersed with long periods of no change.

C. speciation is due to a single mutation.

D. transitional forms of species will be found in the fossil record.

The following information relates to Questions 21 and 22.

The molecular clock suggests that the number of differences in the proteins of two species can be indicative of the time that has elapsed since they diverged from their most recent common ancestor. Protein X has been estimated to change at the rate of one amino acid sub-unit every one million years. This protein is compared between three species of organism and the data is represented in the diagram below.



Question 21

According to the diagram, the number of differences in the amino acid sequence between species A and B are

A. 0

B. 2

C. 4

D. 6

Question 22

While the molecular clock is a powerful tool for inferring evolutionary relationships between species, it does have limitations. Care must be taken when making inferences about species relatedness because

A. different proteins are comprised of different amino acid sub-units.

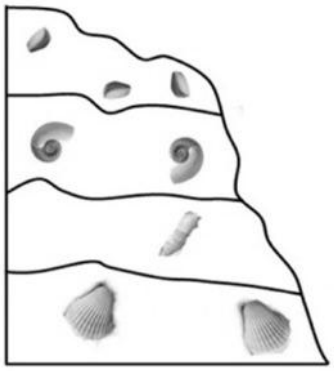
B. the rates of change in a specific protein can differ between species.

C. proteins are subject to mutations.

D. amino acid sub-units are subject to mutations.

The following information relates to Questions 23 and 24.

A profile of rock containing fossils is shown below.



Question 23

What kind of rock is this profile most likely to be made from?

A. metamorphic

B. igneous

C. sedimentary

D. basalt

Question 24

Which of the following statements is true for the diagram?

A. the more recent the layer of rock, the less resemblance there is between the fossils found in it and living organisms.

B. the fossils found in older layers are more specialised than those found in the more recent layers.

C. the number of organisms living today is much greater than the number of extinct species found fossilised.

D. more primitive fossils are found in the lower layers of the profile.

Question 25

After bipedal locomotion, which of the following was next to appear as humans diverged from other primates?

A. domestication of wild animals.

B. making of stone tools.

C. burial of the dead.

D. established language.

END OF SECTION A

END OF SECTION A
TURN OVER

SECTION B – SHORT ANSWER QUESTIONS

Question 1

Turner syndrome (TS) is a chromosomal condition which affects approximately 1 in 2000 females and is typically characterised by short stature, lack of secondary sexual characteristics and infertility. TS is an example of monosomy. The following karyotype is from a female baby with the condition.

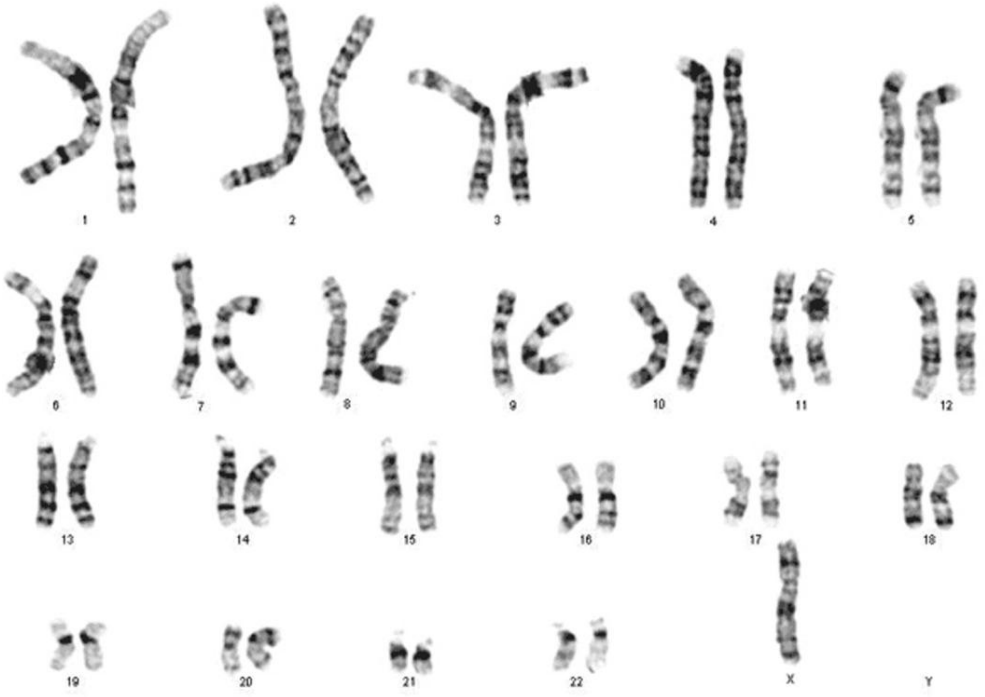


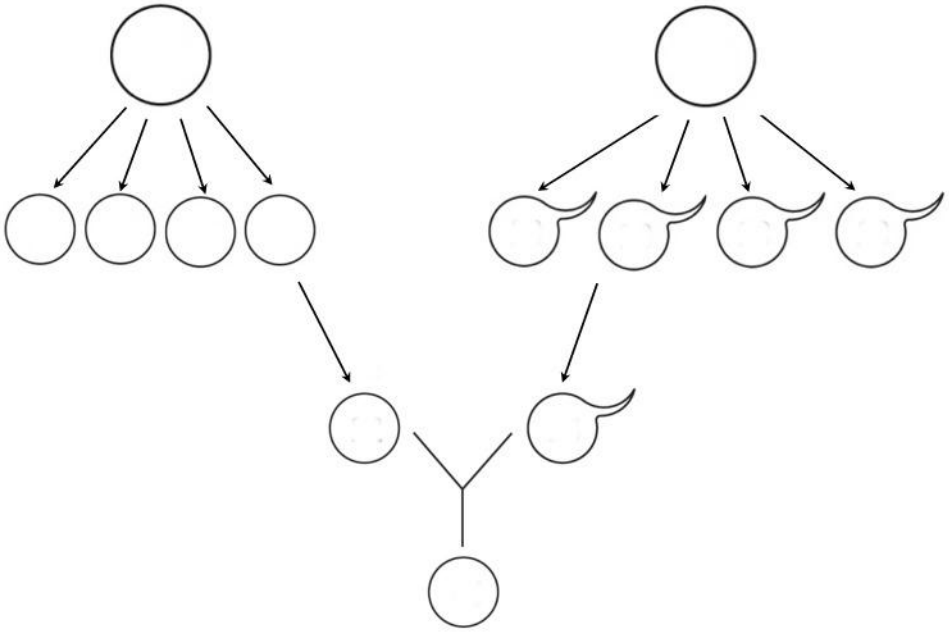
Image source: NSW Health. *The Centre for Genetics Education*.

1a. What is the chromosomal abnormality that causes TS?

_____

1 mark

1b. Write in the correct number of chromosomes in each cell in the diagram to show how TS occurs.



3 marks

1c. What is the name of the process that leads to TS?

_____

1 mark

1d. At what stage of cell division is the process identified in **1c.** most likely to occur?

_____

1 mark

1e. What is the probability of a woman who has TS passing the condition on to her daughters?

_____

_____

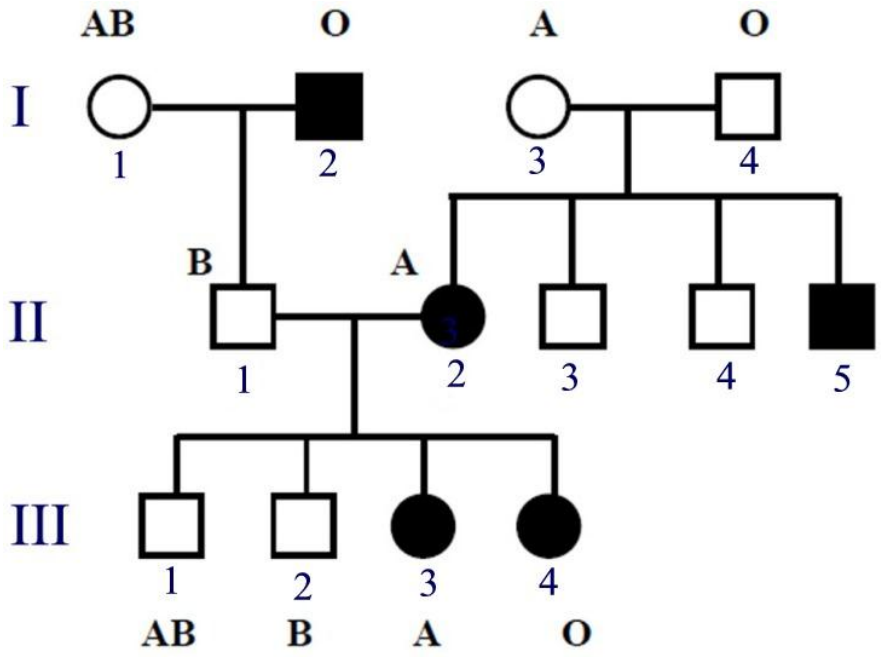
_____

1 mark

Total 1+3+1+1+1 = 7 marks

Question 2

Alkaptonuria is an inherited condition in which the body fails to produce the enzyme homogentisate oxidase which breaks down the amino acids tyrosine and phenylalanine. As a result, a substance called homogentisic acid (HGA) accumulates in the skin and other body tissues. HGA leaves the body through the urine, which turns brownish-black on exposure to air. The three major features of alkaptonuria are the presence of HGA in the urine, ochronosis (bluish-black pigmentation in connective tissue), which usually occurs in the fourth decade, and arthritis of the spine and larger joints which often begins in the third decade. The condition is rare and affects from 1 in 250,000 to 1 in 1 million people worldwide. The *HGD* gene controls the production of homogentisate oxidase and is closely linked to the gene which determines the ABO blood groups. A pedigree of a family with alkaptonuria is shown below. Affected individuals are indicated by the shaded symbols. In addition, the blood group of family members is given.



2a. What is the mode of inheritance of this trait?

_____

1 mark

2bi. Assign appropriate allelic symbols for alkaptonuria.

_____

_____

1 mark

2bii. With respect to alkaptonuria and blood type, what are the genotypes of the following individuals?

Individual	Genotype
I2	
II1	

1 mark

1+1 = 2 marks

2c. What is the chance that the child will have alkaptonuria? Show your working out including the genotypes of II1 and II2.

3 marks

2d. What is the expression used to describe the inheritance pattern shown by the A and B alleles for blood group?

_____

1 mark

Total 1+2+3+1 = 7 marks

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Question 3

In human chromosomes, region 17q21.31 has been studied in detail. It contains the genes for microtubule-associated protein tau (MAPT), corticotrophin releasing hormone receptor 1 (CRHR1) and several other genes.

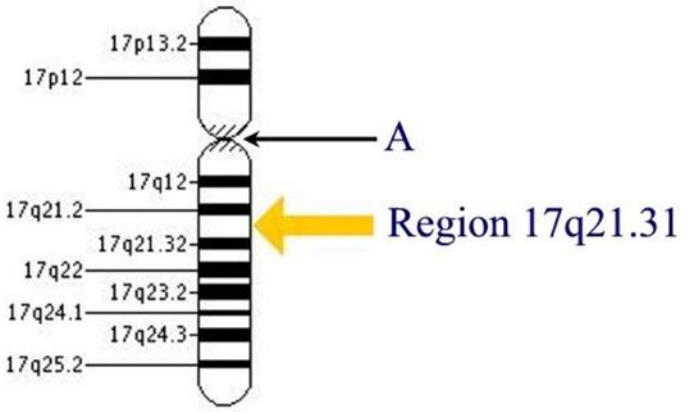


Image source: National Library of Medicine (NLM)

3a. Identify the structure and its function at A.

_____

_____

1 mark

In human chromosomes, the region occurs as two haplotypes, H1 (normal orientation) and H2 (inverted orientation). A haplotype is a group of closely located alleles (for different genes) that are found on the same chromosome and usually inherited together. The H2 inverted haplotype is found in 21% of northern Europeans (in 20% of Icelandic people), 6% of Africans and 1% of Asians. Icelandic women with this chromosomal inversion have significantly more children than women without it.

3b. What is a chromosomal inversion?

_____

_____

1 mark

3c. Predict what will happen to the frequency of the H2 inversion in the Icelandic population in future generations.

_____

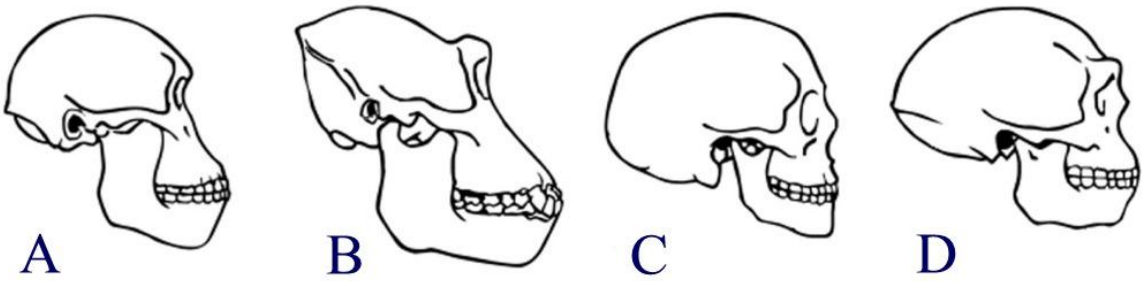
_____

_____

1 mark

When chromosomal inversions occur, they are associated with increased rates of recombination, which result in highly divergent lineages. The pronounced divergence between the H1 and H2 lineages suggests that the H2 lineage was introduced into the ancestral human gene pool in Africa from species such as *Homo heidelbergensis* or *Homo erectus*. There is even a possibility that their separation potentially pre-dated the genus *Homo*.

The following diagram shows the skulls of four primates. All of the primates are members of the family Hominidae but not all are hominins. Hominins can be distinguished from other primates by their upright and bipedal locomotion. The only living hominins are humans, all other hominins are extinct.



3di. Identify two forms of evidence that enable palaeobiologists to determine if a fossil species walked upright.

Evidence 1:

_____

Evidence 2:

_____

2 marks

3dii. Identify the hominin skulls in the diagram and outline two differences that enable you to distinguish them from other hominids.

Hominin skull(s):

_____

Difference 1:

_____

_____

Difference 2:

_____

_____

3 marks

2+3=5 marks

Total 1+1+1+5 = 8 marks

Question 4

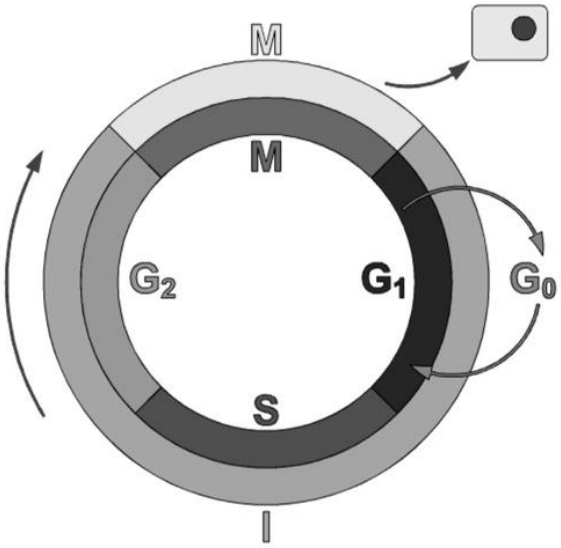
In humans, protein 53, encoded by the *p53* gene, is directly involved in the regulation of the cell cycle. The *p53* is found on chromosome 17 and is located at region 17p13.1. The diagram shows an intron from the *p53* gene.

4a. What is the size of the *p53* gene?

_____

1 mark

If DNA is damaged, *p53* can activate DNA repair proteins, trigger growth arrest by halting the cell cycle so that damaged DNA can be repaired before the next division cycle, and initiate apoptosis. The diagram shows a representation of the cell cycle.



4b. Use a labelled arrow to indicate where repair to damaged DNA is most likely to occur during the cell cycle.

1 mark

4c. What is apoptosis and why does it occur?

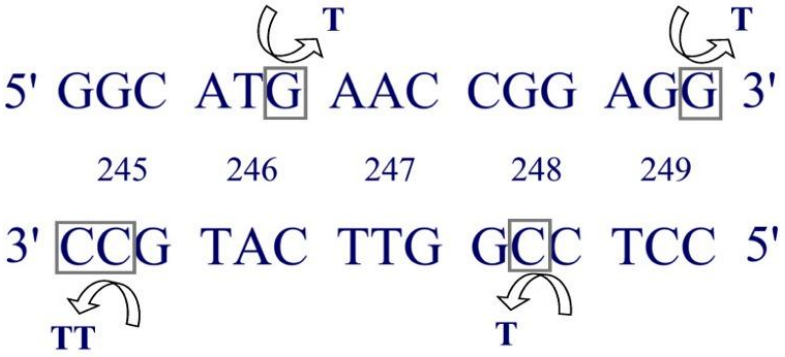
_____

_____

_____

1 mark

The action of four carcinogens on part of a normal sequence of the *p53* gene is shown below.



4di. What is the name given to these changes?

_____

1 mark

4dii. Using the information from the normal sequence of *p53*, complete the following table.

original DNA	GGC ATG AAC CGG AGG
mutant DNA	
tRNA	

2 marks

1+2=3 marks

Total 1+1+1+3 = 6 marks

Question 5

The three-dimensional structure shown below is produced in the nucleus and then moves to the cytoplasm. It is about 80 nucleotides long and is directly involved in the production of a polypeptide.

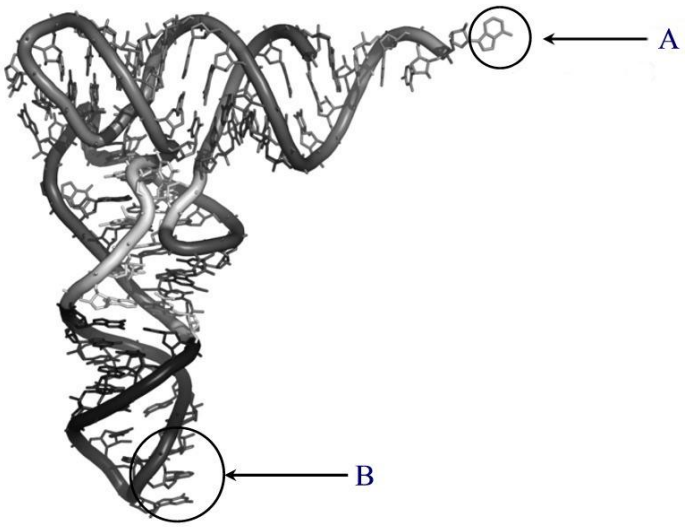


Image source: The Full Wiki. (Structural Biochemistry/Nucleic Acid/RNA/Transfer RNA (tRNA): Wikis)

5a. What is this molecule?

_____

1 mark

5b. What is the significance of Site A and Site B?

_____

_____

1 mark

5c. Clearly explain what happens to the molecule shown in the diagram during the formation of a polypeptide.

_____

_____

_____

_____

_____

_____

_____

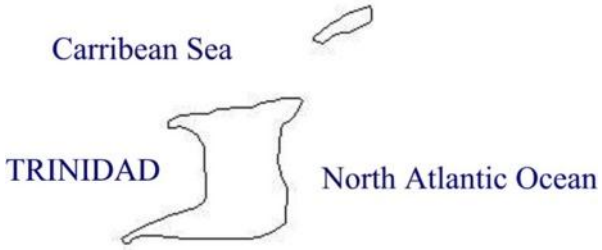
_____

2 marks

Total 4 marks

Question 6

The guppie, *Poecilia reticulata*, is a small freshwater fish that occurs in Trinidad, an island in the Caribbean.



In wild populations, the patterns on adult male guppies vary significantly from brightly coloured to drab. Female guppies are attracted to brightly coloured males. The guppy has two main predators, the killifish *Rivulus hartii*, which preys on juvenile guppies which have not expressed their adult colouring and the pike-cichlid *Crenicichla alta*, which preys principally on adult guppies.

Colour patterns in the guppy are under the control of many genes which are only expressed in adult males.

6a. What causes the colour pattern phenotype in guppies?

_____

1 mark

.

In wild populations of guppies, males in pools with few predator species tend to be brightly coloured whereas those in pools with many predators are less brightly coloured. When brightly coloured guppies are transferred to pools with many predators, over time the transferred guppy populations become less brightly coloured.

6bi. Identify the process that has occurred in the transferred population of guppies.

_____

1 mark

6bii. Explain how the process in **part i** produces the differences in colour in the populations of guppies.

_____

_____

_____

_____

_____

_____

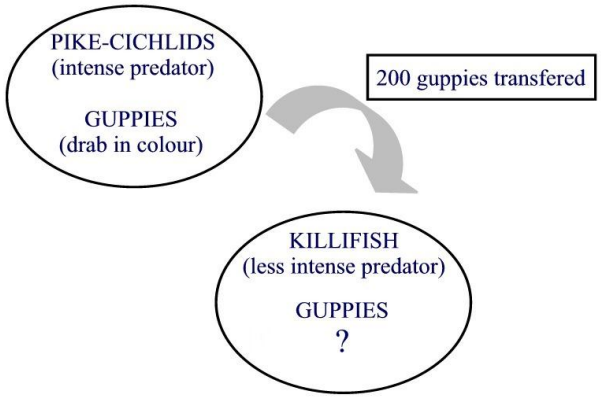
_____

_____

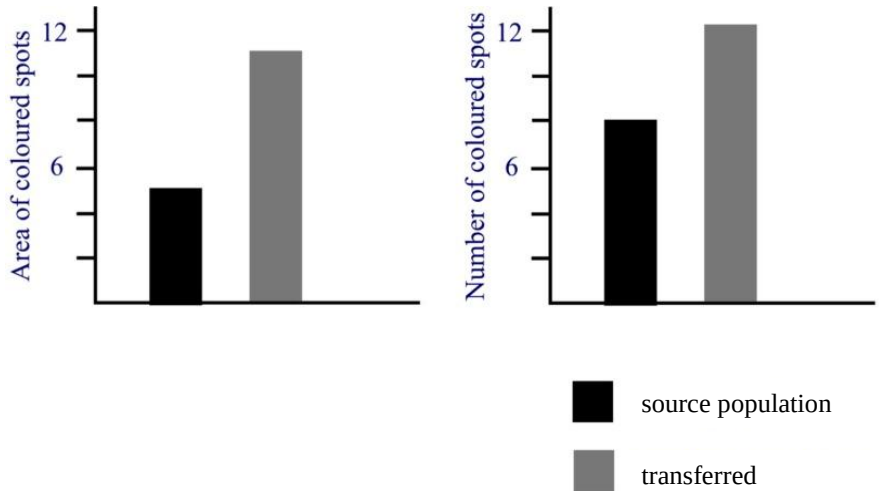
3 marks

1+3 = 4 marks

An experiment was carried out to study the impact of predators on guppies. At the beginning of the two-year experiment, 200 guppies from pools containing only pike-cichlids (intense guppy predators) were transferred to pools containing killifish (less intense guppy predators). The number of brightly coloured spots and the total area of these spots were recorded for the male guppies in all of the 15 generations.



The graphs show the results of the experiment.



6ci. What conclusion could be drawn from the results of this experiment?

_____

_____

_____

1 mark

6cii. Identify the type of change that has occurred in the transferred population.

_____

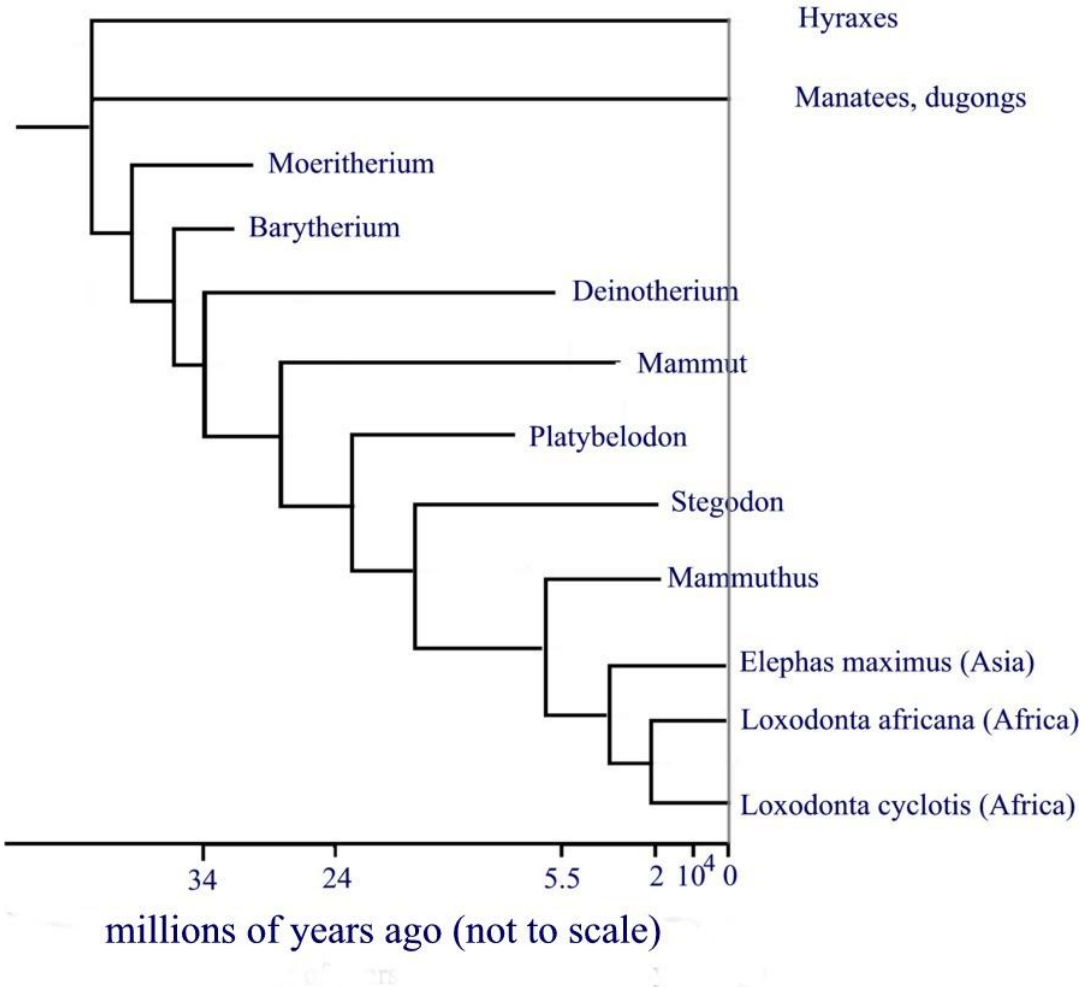
1 mark

1+1 = 2 marks

Total 1+ 4 + 2 = 7 marks

Question 7

In the past, African elephants found in the African savanna and forests, were classified as a subspecies of the same species. Studies of the mitochondrial DNA from African elephants found evidence of interbreeding between forest and savanna elephants around 500 000 years ago. A phylogenetic tree of elephants and their relatives, developed prior to the 2010 study, is shown below. (Note: the time line is not to scale.)



7ai. Based on the phylogenetic tree shown above, approximately how long ago did the African elephants evolve from their common ancestor?

_____

1 mark

7aii. Identify one extant relative of the Asian and African elephants.

_____

1 mark

1+1 = 2 marks

The following table shows some comparisons between the African forest elephant and the African savanna elephant.

	African forest elephant (*Loxodonta cyclotis)*	**African savanna elephant** (*Loxodonta africana)*
shoulder height	male 2.4–2.8 m female 1.8–2.4 m	male 4 m female 2.2–2.6 m
weight	male 4 000–6 300 kg female 2 400–3 500 kg	2 700–6 000 kg
family group	nuclear family group size = 2–4	extended family group size = 4–14

7b. Explain whether the African elephants could be classified as separate species on the basis of the information in the table.

_____

_____

_____

_____

_____

_____

_____

2 marks

In 2010, the results of a new study indicated that the African forest elephant, *Loxodonta cyclotis*, and African savanna elephant, *Loxodonta africana*, are as genetically distinct from one another as the Asian elephant and the extinct woolly mammoth. In contrast with earlier research, the study sequenced the nuclear genomes of both types of African elephant, and of the Asian elephant (*Elephas maximus*). They also extracted and sequenced nuclear DNA from the extinct woolly mammoth (*Mammuthus primigenius*) and mastodon (*Mammut americanum*). Comparison of the five genomes found that the forest and savanna elephants diverged into separate species between 2.6 and 5.6 million years ago. This was around the same time as African and Asian elephants separated into separate species.

7c. Give a reason why researchers sequenced the nuclear genomes of the elephants and not just their mitochondrial DNA.

_____

_____

_____

2 marks

All female African elephants stay close to their place of birth while all male African elephants roam freely.

7d. What is likely to happen to the African forest elephant gene pool over a long period?

_____

_____

_____

_____

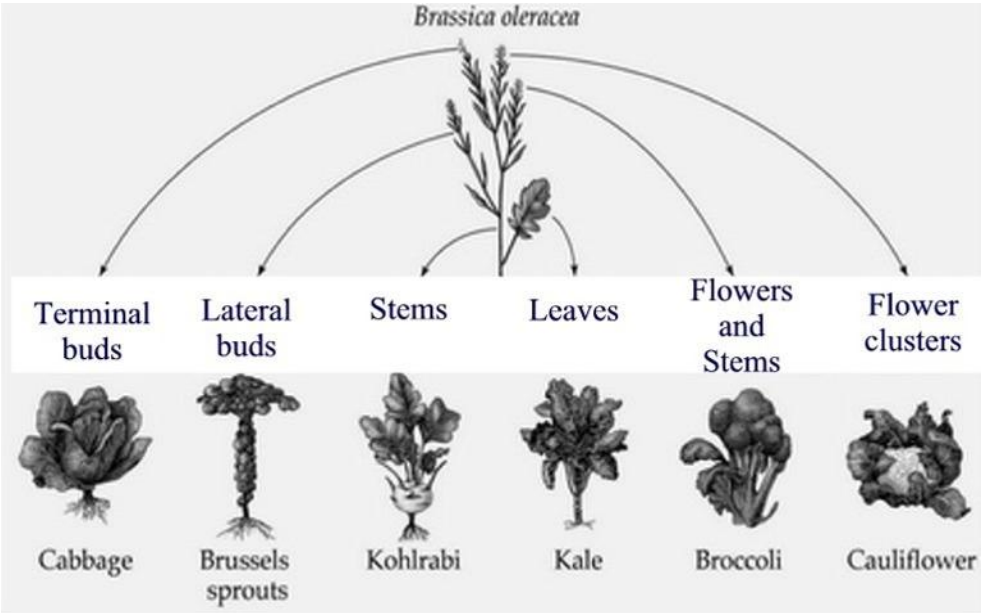
_____

1 mark

Total 2+2+2+1 = 7 marks

Question 8

The vegetables shown in the diagram are all varieties of the wild cabbage species *Brassica oleracea*. Farmers have cultivated many different crops on the basis of the various attributes of the plant.



8a. Identify and explain the form of selection the farmers have engaged in.

_____

_____

2 marks

Canola seeds are produced by flowering plants in the Brassica family. The seeds are pressed to produce canola oil which has the lowest level of saturated fatty acids of any vegetable oil. Canola plants usually self-pollinate and pollen from other canola plants is usually outcompeted. However, airborne cross-pollination can occur if crops are found within metres of each other. Canola pollen is quite heavy and cannot remain airborne for more than a few metres. In addition, pollen dries out quickly and loses its ability to pollinate. After the western Victorian floods in January 2011, concerns over genetically modified (GM) seed contamination have been raised. The company holding the patent for GM canola technology stated that GM canola and non-GM canola crops can co-exist.

8b. Should western Victorian farmers with adjoining properties be concerned about contamination between their GM and non-GM crops?

_____

_____

_____

_____

2 marks

Total 2 + 2 = 4 marks

END OF SECTION B

END OF QUESTION AND ANSWER BOOK